varieties following the indication of *Coccinella* 10-*punctata*, L., and 6 or 8 analogous varieties are appended to many other species of Ladybirds. Taking it as a whole, this excellent catalogue may serve as a model for compilers of lists of the Beetle (or other entomological) fauna of other districts.

LETTERS TO THE EDITOR

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.

[The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to ensure the appearance even of communications containing interesting and novel facts.]

Equal Temperament of the Scale

IN your number of November 8, 1877, p. 34, Mr. Chappell, F.S.A., has intimated that mathematicians who propose to divide the octave into twelve equal semitones instead of " equally tempered semitones," are deficient in musical ear. I have not noticed that any mathematician has replied to him.

Representing (with Mr. Chappell) the number of vibrations in the C of my piano by 1, and the octave *c* therefore by 2, and dividing the octave into 12 equal intervals, I obtain for the vibration-numbers—

$$C = 1$$
$$C\sharp = 1\cdot0594 = 2^{\frac{1}{12}}$$
$$D = 1\cdot1224 = 2^{\frac{2}{12}}$$
$$D\sharp = 1\cdot1892 = 2^{\frac{3}{12}}$$
$$E = 1\cdot2599 = 2^{\frac{4}{12}}$$
$$F = 1\cdot3348 = 2^{\frac{5}{12}}$$
$$F\sharp = 1\cdot4142 = 2^{\frac{6}{12}}$$

$$G = 1\cdot4983 = 2^{\frac{7}{12}}$$
$$G\sharp = 1\cdot5874 = 2^{\frac{8}{12}}$$
$$A = 1\cdot6818 = 2^{\frac{9}{12}}$$
$$B\flat = 1\cdot7818 = 2^{\frac{10}{12}}$$
$$B = 1\cdot8877 = 2^{\frac{11}{12}}$$
$$c = 2$$

In these equal semitones each is equidistant from the preceding and following: as F is to F$\sharp$, so is F$\sharp$ to G, &c. Hence in whatever key I play a passage on my piano, the divergence from harmonic intervals will be alike at every point; the keys on my piano will have no distinctive character, the key of 3 sharps will not be more " brilliant " or less " plaintive " than that of 4 flats.

In the key of C, the harmonic third, fifth, and seventh will be, according to the above notation, 1·25, 1·5, and 1·75 respectively. As regards the fifth G it is a remarkable numerical coincidence that $2^{\frac{7}{12}}$ only differs from 1·5 by $\frac{1}{400}$, *i.e.* the equal temperament G only differs from the harmonic by its $\frac{1}{400}$ part, a difference so slight that it may be neglected. We tune fiddles by fifths therefore. This coincidence is the fundamental fact which enables us to modulate into various keys on a piano, and it is the reason why the scale must be divided into 12 (and not any other number of) semitones; for it will be found that, until you get to the unmanageably high number of 53, no other equal division of the scale has any note so near the harmonic G.

The crucial point of tempering arises on the third. The E of my piano is $2^{\frac{1}{3}} = \frac{126}{100}$, whereas the harmonic E is $= \frac{125}{100}$; my E is therefore by its $\frac{1}{80}$ part too sharp, *in the key of C*, a perceptible degree of error, unpleasant to many musicians. In ordinary pianoforte tuning, the E (by the plan in Hamilton's pianoforte tuner or some similar compromise) is tuned somewhere between $\frac{125}{100}$ and $\frac{126}{100}$, say $\frac{125\frac{1}{2}}{100}$, and the wolf between this E and the upper *c* is distributed.

This is all very simple so long as we remain in the key of C; indeed if we remain there, we want no tempering. But G$\sharp$ is the third to E, and *c* is the third to A$\flat$; on the piano G$\sharp$ and A$\flat$ are one. On my equal-semitone piano I have

$$c = 1 ; E = 2^{\frac{1}{3}} (= \tfrac{126}{100} \text{ nearly}) ;$$
$$G\sharp = A\flat = 2^{\frac{2}{3}} (= \tfrac{157}{100} \text{ nearly}) ; c = 2.$$

I now ask the champion of " equally tempered semitones " what is the numerical value of his E and what of his G$\sharp$. If he gives them any other values than $2^{\frac{1}{3}}$ and $2^{\frac{2}{3}}$ respectively, it is clear that a *greater* error will be introduced in one part of the scale

than is saved in another. Instead of algebraic proof I take an instance—suppose that Mr. Chappell tunes his E at $\frac{125\frac{1}{2}}{100}$; if he equally tempers his G$\sharp$ in the scale of E, it will be $\left(\frac{125\frac{1}{2}}{100}\right)^2 = \frac{31}{20}$ very nearly. Then when he puts down the common chord in the key of A$\flat$, his third the *c* will be by its $\frac{1}{32}$ part too sharp, whereas on my equal temperament piano it would only be by its $\frac{1}{80}$ part too sharp. In other words, though the keys of C and E may be somewhat better on Mr. Chappell's piano than on mine, the key of A$\flat$ will be *very much* worse. This is pretty nearly what occurs in practice. The point of my argument is that Mr. Chappell cannot move his E ever so little from the value $2^{\frac{1}{3}}$ without introducing a greater error somewhere else. The term " equally tempered semitone " is inaccurate ; the semitones on my piano are all equal ; and no one of them can be altered by a disciple of the " equally-tempered semitone " without making them unequal. The " equally-tempered semitones " are *not* equally tempered. Moreover if you " temper " *at all* you lose the effect of the harmonics ; by moving E from $\frac{125}{100}$ to $\frac{125\frac{1}{2}}{100}$ you sacrifice harmonic coincidence.

The simple reason that unequal tempering is practised is because all keys are not used equally often. A piano is unequally tempered so that the keys C, G, A, F are fair, E, B$\flat$, E$\flat$ tolerable, the other keys being very much worse than on my equal-semitone piano. On most church organs, being unequally tempered, if you modulate even transiently into 4 or 5 flats, the effect is unendurable.

The crucial question in tuning is the question, if your E is not $2^{\frac{1}{3}}$ and your G$\sharp$ $2^{\frac{2}{3}}$, what values do you put them at? The question of the seventh is more complex ; I may observe that though my equal-semitone seventh (1·7818) appears far away from the harmonic seventh (1·75), yet that the B$\flat$ of tuners on the " equally-tempered semitone " system is not much nearer it. Their B$\flat$ is $\frac{16}{9}$ or thereabout, or in other words, the sub-subdominant of C. Therefore, on the piano, you have not got the " harmonic-seventh " at all ; the note which replaces it is one that suggests overpoweringly the key of F. This is the secret which underlies several of our rules in harmony. It is also the reason why valve-horn players play B$\flat$ (though an open note) with valve *n*.2, or if they play without a key " lip it up " very carefully.

It is often supposed that the " wolf " has been introduced into music by that most useful though imperfect instrument the piano, and that the noble violin or human voice knows it not, except in so far as our natural good ear for harmonic intervals has been debauched by continually hearing tempered intervals. This is not so ; the " wolf " is not only in the piano but in the scale. It is true that a violin can play in harmonic tune so long as the melody runs in one key, or if it modulates into a closely allied key, and *back again the same way*. But suppose my violin begins by rising from C to E harmonically, *i.e.* to $\frac{125}{100}$; then after playing awhile there proceeds to G$\sharp$ $(\frac{125}{100})^2$ harmonically, being then in 8 sharps ; and then, after playing awhile in 8 sharps, proceeds to *c* ; the *c* of the fiddle will then be $(\frac{125}{100})^3$ instead of 2, *i.e.* it will be $\frac{3}{28}$ out of tune. In this simple case the fiddle is supposed to play alone, unfettered by any harmonics but its own ; in the case of a string-band, the agreeableness of many modulations actually depends upon some chords being harmonically out of tune, the note in the chord which performs the duty of G$\sharp$ to its preceding chord, performing the duty of A$\flat$ to its succeeding chord.

The practical conclusion is that the best plan of tuning a piano for vulgar music and vulgar players is that now ordinarily practised by the tuners, and recommended by Mr. Chappell ; but if the piano is to be used equally in all keys (or even frequently in 4 or 5 flats, 5 or 6 sharps) the best plan is to tune it in 12 mathematically equal semitones.   C. B. CLARKE

Animal Intelligence

IN an excellent paper on " Animal Intelligence " (NATURE, vol. xxvi. p. 523), Mr. C. Lloyd Morgan says that " The brute has to be contented with the experience he inherits or individually acquires. Man, through language spoken or written, profits by the experience of his fellows. Even the most savage tribe has traditions extending back to the father's father. May there not be, in social animals also, traditions from generation

to generation, certain habits prevailing in certain communities in consequence neither of inherited instincts nor of individual experience, but simply because the young ones imitate what they see in their elder fellows?

As is well known, the stingless honey-bees (*Melipona* and *Trigona*) build horizontal combs consisting of a single layer of cells, which, if there is plenty of space, are of rather regular shape, the peripheral cells being all at about the same distance from the first built central one. Now, on February 4, 1874, I met with a nest of a small Trigona ("Abelha preguicosa") in a very narrow hole of an old canella-tree, where, from want of space they were obliged to give to their combs a very irregular shape, corresponding to the transversal section of the hole. These bees lived with me, in a spacious box, about a year (till February 10, 1875), when perhaps not a single bee survived of those which had come from the canella-tree; but notwithstanding they yet continued to build irregular combs, while quite regular ones were built by several other communities of the same species, which I have had.

The following case is still more striking. In the construction of the combs for the raising of the young, as well as of the large cells for guarding honey and pollen, our *Meliponæ* and *Trigonæ* do not use pure wax, but mix it with various resinous and other substances, which give to the wax a peculiar colour and smell. Now I had brought home from two different and distant localities two communities of our most common *Melipona* (allied to *M. marginata*), of which one had dark reddish-brown, and the other pale yellowish-brown wax, they evidently employing resin from different trees. They lived with me for many years, and either community continued, in their new home, to gather the same resins as before, though now, when they stood close together, any tree was equally accessible to the bees of either community. This can hardly be attributed to inherited instinct, as both belonged to the same species, nor to individual experience about the usefulness of the several resins (which seemed to serve equally well), but only, as far as I can judge, to tradition, each subsequent generation of young bees following the habits of their elder sisters.　　　　　FRITZ MUELLER

Blumenau, St. Catharina, Brazil, November 14, 1882

The Inventor of the Incandescent Electric Light

IN the "Notes" of NATURE, vol. xxvii. p. 209, M. de Chagny is described as "the first electrician who attempted to manufacture incandescent lamps *in vacuo* about twenty years ago." This invention and its successful practical application (irrespective of cost) was made by a young American, Mr. Starr, and patented by King in 1845. A short stick of gas-retort carbon was used, and the vacuum obtained by connecting one end of this with a wire sealed through the top of a barometer tube blown out at the upper part, and the other end with a wire dipping into the mercury. The tube was about thirty-six inches long, and thus the enlarged upper portion became a torrecellian vacuum when the tube was filled and inverted. I had a share of one-eighth in the venture, assisted in making the apparatus and some of the experiments, and after the death of Mr. Starr all the apparatus was assigned to me. I showed this light (in the original lamp) publicly many times at the Midland Institute, Birmingham, and on two occasions in the Town Hall, all of them more than twenty years ago. The light was far more brilliant, and the carbon-stick more durable, than the flimsy threads of the incandescent lamps now in use. It was abandoned solely on account of the cost of supplying the power. As a steady, reliable, and beautiful light, its success was complete. In "A Contribution to the History of Electric Lighting," published in the *Journal of Science*, November 5, 1879, and reprinted lately in my "Science in Short Chapters," may be found further particulars concerning this invention and its inventor.　　　　　W. MATTIEU WILLIAMS

Stonebridge Park, N.W.

The Reversion of Sunflowers at Night

WHILE the fact that sunflowers turn their faces toward the sun in its course during the day is as old as our knowledge of the plant, I am not aware that any record has been made as to the time of night that they turn to the east again after their obeisance to the setting sun.

One evening during a short stay at a village in Colorado, in the summer of 1881, I took a walk along the banks of a large

irrigating ditch just as the sun was setting. The wild variety of *Helianthus annuus*, Lin. (= *H. lenticularis*, Douglass) grew abundantly there, and I observed that the broad faces of all the flowers were, as is usual in the clear sunset, turned to the west. Returning by the same path less than an hour afterwards, and immediately after the daylight was gone, I found, to my surprise, that much the greater part of those flowers had already turned their faces full to the east in anicipation, as it were, of the sun's rising.

They had in that short time retraced the semi-circle, in the traversing of which with the sun they had spent the whole day. Both the day and night were cloudless, and apparently no unusual conditions existed that might have exceptionally affected the movements of the flowers.

I doubt not that many persons like myself have supposed that sunflowers remain all night with their faces to the west, as they are when the sunlight leaves them, and until they are constrained by the light of the rising sun, to turn to the east again. It is not my purpose to offer any explanation of the cause of the phenomenon here recorded, but it seems to me improbable that it could have been an exceptional instance; and I only regret that no opportunity has since occurred to me to repeat the observation.

Washington, December 26　　　　　C. A. WHITE

Pollution of the Atmosphere

MR. H. A. PHILLIPS, in NATURE, vol. xxvii. p. 127, thinks that the effect of the increasing quantity of hydrocarbons in the air from the combustion of coal will be to make climates more extreme. It seems to me the effect will be the direct contrary. Gaseous and vaporous hydrocarbons absorb heat much more powerfully than air, and whatever makes the atmosphere absorb and retain more solar heat than at present will tend to equalise temperatures between day and night, and also between different latitudes. I think, however, that any possible effect of hydrocarbons will be quite insignificant in comparison with the effect of the watery vapour of the atmosphere, which, as Tyndall has shown, moderates climates by its power of absorbing solar heat.　　　　　JOSEPH JOHN MURPHY

Old Forge, Dunmurry, Co. Antrim, December 28, 1882

A "Natural" Experiment in Complementary Colours

ON page 79 of vol. i. of the "Life, Letters and Journal of Sir Charles Lyell," his visit to the Fall of the Rhine at Schaffhausen is described, and he notes that "as the sun shone on the foam it took very much the rose-coloured tint so remarkable on the snow in the Alps."

His experience as regards the colour being observed in the full sunlight seems to differ from that of Mr. Chas. T. Whitmell, which you published in NATURE, vol. xxvi. p. 573.

E. J. BLES

Moor End, Kersal, near Manchester, January 8

BAIRDS' HARE AND ITS HABITS

SEVERAL instances have been recorded in which individual male mammals have produced milk from their mammary glands for the nutriment of their young. But that the young of a mammal should be ordinarily suckled by the male parent is such an extraordinary anomaly that it is very hard to believe it. Yet that such is the case in an American species of hare (*Lepus bairdii*) would seem to be highly probable from observations made by Dr. Hayden and his party during one of their expeditions in the Yellowstone Mountains. In the last number of the *American Naturalist*, Mr. Lockwood gives the following details on this curious subject :—

"In the months of May and June, 1860, Prof. F. V. Hayden and his party of United States explorers found themselves up in the Alpine snows of the Wind River Mountains, where they were detained several days in an attempt to feel their way to the Yellowstone. On May 31 Dr. Hayden declared that a new species of hare was around, as he had observed unusually large hare-tracks in the snow. As the Doctor expressed himself to us :— The tracks were very large, the feet being wide-spread, and the hair thick between the toes, thus really furnishing